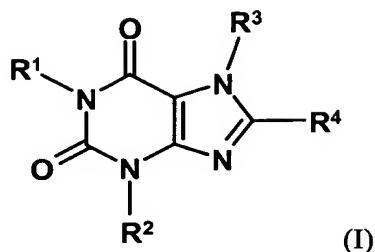


We Claim:

1. A compound of formula (I)



wherein:

R¹ is a phenylcarbonylmethyl group wherein the phenyl moiety is substituted by R¹⁰ and R¹¹, wherein:

R¹⁰ is a formylamino, a C₃₋₇-cycloalkyl-carbonylamino, C₃₋₇-cycloalkyl-C₁₋₃-alkyl-carbonylamino, C₆₋₉-bicycloalkyl-carbonylamino, C₆₋₉-bicycloalkyl-C₁₋₃-alkyl-carbonylamino, C₄₋₇-cycloalkenyl-carbonylamino, C₄₋₇-cycloalkenyl-C₁₋₃-alkyl-carbonylamino, C₃₋₇-cycloalkyl-sulfonylamino, C₃₋₇-cycloalkyl-C₁₋₃-alkyl-sulfonylamino, arylsulfonylamino, aryl-C₁₋₃-alkyl-sulfonylamino, or a heteroarylcabonylamino group,

a C₅₋₇-cycloalkyl-carbonylamino group wherein a methylene group is replaced by an oxygen or sulfur atom or by an imino, sulfinyl, or sulfonyl group,

a C₅₋₇-cycloalkyl-carbonylamino group wherein a -CH₂-CH₂ group is replaced by a -NH-CO or -NH-NH group,

a C₅₋₇-cycloalkyl-carbonylamino group wherein a -CH₂-CH₂-CH₂ group is replaced by a -NH-CO-NH, -NH-CO-O, or -O-CH₂-O group,

a C₆₋₇-cycloalkyl-carbonylamino group wherein a -CH₂-CH₂-CH₂-CH₂ group is replaced by a -NH-CH₂-CH₂-NH, -NH-CO-CH₂-NH, -NH-CH₂-CH₂-O, -NH-CO-CH₂-O, or -O-CH₂-CH₂-O group,

a cycloheptyl-carbonylamino group wherein a -CH₂-CH₂-CH₂-CH₂-CH₂ group is replaced by a -NH-CH₂-CH₂-CH₂-NH, -NH-CO-CH₂-CH₂-NH, -NH-CH₂-CH₂-CH₂-O, -NH-CO-CH₂-CH₂-O, or -O-CH₂-CH₂-CH₂-O group, or

a C₅₋₇-cycloalkyl-carbonylamino group wherein one or two methylene groups are replaced by carbonyl groups,

wherein the imino groups in the abovementioned groups are optionally independently substituted by a C₁₋₃-alkyl group; and

R¹¹ is a hydrogen, fluorine, chlorine, bromine, or iodine atom or a C₁₋₃-alkyl, C₁₋₃-alkyloxy, difluoromethyl, trifluoromethyl, difluoromethoxy, trifluoromethoxy, or cyano group;

R² is a hydrogen atom, or a C₁₋₆-alkyl, C₂₋₄-alkenyl, C₃₋₄-alkynyl, C₃₋₆-cycloalkyl, C₃₋₆-cycloalkyl-C₁₋₃-alkyl, tetrahydrofuran-3-yl, tetrahydropyran-3-yl, tetrahydropyran-4-yl, tetrahydrofuranylmethyl, tetrahydropyranylmethyl, aryl, aryl-C₁₋₄-alkyl, aryl-C₂₋₃-alkenyl, arylcarbonyl-C₁₋₂-alkyl, heteroaryl-C₁₋₃-alkyl, furanylcabonylmethyl, thienylcarbonylmethyl, thiazolylcarbonylmethyl, pyridylcarbonylmethyl, C₁₋₄-alkyl-carbonyl-C₁₋₂-alkyl, or C₃₋₆-cycloalkyl-carbonyl-C₁₋₂-alkyl group,

an aryl-D-C₁₋₃-alkyl group, wherein D is an oxygen or sulfur atom, or an imino, C₁₋₃-alkylimino, sulfinyl, or sulfonyl group,

a C₁₋₄-alkyl group substituted by a group R_a, wherein R_a is a cyano, carboxy, C₁₋₃-alkyloxy-carbonyl, aminocarbonyl, C₁₋₃-alkylamino-carbonyl, di-(C₁₋₃-alkyl)-amino-carbonyl,

pyrrolidin-1-ylcarbonyl, piperidin-1-ylcarbonyl, morpholin-4-ylcarbonyl, piperazin-1-ylcarbonyl, 4-methylpiperazin-1-ylcarbonyl, or 4-ethylpiperazin-1-ylcarbonyl group, or

a C₂₋₄-alkyl group substituted by a group R_b, wherein R_b is a hydroxy, C₁₋₃-alkyloxy, amino, C₁₋₃-alkylamino, di-(C₁₋₃-alkyl)-amino, pyrrolidin-1-yl, piperidin-1-yl, morpholin-4-yl, piperazin-1-yl, 4-methylpiperazin-1-yl, or 4-ethylpiperazin-1-yl group and is isolated from the cyclic nitrogen atom in the 3 position of the xanthine skeleton by at least two carbon atoms;

R³ is a C₃₋₈-alkyl, C₃₋₈-alkenyl, C₃₋₈-alkynyl, aryl, or aryl-C₂₋₄-alkenyl group,

a C₁₋₃-alkyl group substituted by a group R_c, wherein:

R_c is a C₃₋₇-cycloalkyl group optionally substituted by one or two C₁₋₃-alkyl groups, a C₅₋₇-cycloalkenyl group optionally substituted by one or two C₁₋₃-alkyl groups, or an aryl group, or

a furanyl, thienyl, oxazolyl, isoxazolyl, thiazolyl, isothiazolyl, pyridyl, pyridazinyl, pyrimidyl, or pyrazinyl group, optionally substituted by one or two C₁₋₃-alkyl groups or by a fluorine, chlorine, bromine, or iodine atom or by a trifluoromethyl, cyano, or C₁₋₃-alkyloxy group, or

a C₃₋₆-alkenyl group substituted by a fluorine, chlorine, or bromine atom, or a trifluoromethyl group;

R⁴ is an azetidin-1-yl or pyrrolidin-1-yl group substituted in the 3 position by an amino, C₁₋₃-alkylamino, or a di-(C₁₋₃-alkyl)amino group optionally additionally substituted by one or two C₁₋₃-alkyl groups,

a piperidin-1-yl or hexahydroazepin-1-yl group is substituted in the 3 position or 4 position by an amino, C₁₋₃-alkylamino, or a di-(C₁₋₃-alkyl)amino group and optionally additionally substituted by one or two C₁₋₃-alkyl groups,

a 3-aminopiperidin-1-yl group wherein the piperidin-1-yl moiety is optionally additionally substituted by an aminocarbonyl, C₁₋₂-alkyl-aminocarbonyl, di-(C₁₋₂-alkyl)aminocarbonyl, pyrrolidin-1-ylcarbonyl, (2-cyanopyrrolidin-1-yl)carbonyl, thiazolidin-3-ylcarbonyl, (4-cyanothiazolidin-3-yl)carbonyl, piperidin-1-ylcarbonyl, or morpholin-4-ylcarbonyl group,

a 3-aminopiperidin-1-yl group wherein the piperidin-1-yl moiety is additionally substituted in the 4 position or 5 position by a hydroxy or methoxy group,

a 3-aminopiperidin-1-yl group wherein the methylene group in the 2 position or 6 position is replaced by a carbonyl group,

a piperidin-1-yl or hexahydroazepin-1-yl group substituted in the 3 position by an amino, C₁₋₃-alkylamino or di-(C₁₋₃-alkyl)-amino group, wherein in each case two hydrogen atoms on the carbon skeleton of the piperidin-1-yl or hexahydroazepin-1-yl group are replaced by a straight-chain alkylene bridge, this bridge containing 2 to 5 carbon atoms if the two hydrogen atoms are on the same carbon atom, or 1 to 4 carbon atoms if the hydrogen atoms are on adjacent carbon atoms, or 1 to 4 carbon atoms if the hydrogen atoms are on carbon atoms which are separated by one atom, or 1 to 3 carbon atoms if the hydrogen atoms are on carbon atoms which are separated by two atoms,

an azetidin-1-yl, pyrrolidin-1-yl, piperidin-1-yl, or hexahydroazepin-1-yl group substituted by an amino-C₁₋₃-alkyl, C₁₋₃-alkylamino-C₁₋₃-alkyl, or a di-(C₁₋₃-alkyl)amino-C₁₋₃-alkyl group,

a piperazin-1-yl or [1,4]diazepan-1-yl group optionally substituted on the carbon skeleton by one or two C₁₋₃-alkyl groups,

a 3-iminopiperazin-1-yl, 3-imino-[1,4]diazepan-1-yl, or 5-imino-[1,4]diazepan-1-yl group optionally substituted on the carbon skeleton by one or two C₁₋₃-alkyl groups,

a [1,4]diazepan-1-yl group optionally substituted by one or two C₁₋₃-alkyl groups substituted in the 6 position by an amino group,

a C₃₋₇-cycloalkyl group substituted by an amino, C₁₋₃-alkylamino, or di-(C₁₋₃-alkyl)-amino group,

a C₃₋₇-cycloalkyl group substituted by an amino-C₁₋₃-alkyl, C₁₋₃-alkylamino-C₁₋₃-alkyl, or a di-(C₁₋₃-alkyl)amino-C₁₋₃-alkyl group,

a C₃₋₇-cycloalkyl-C₁₋₂-alkyl group wherein the cycloalkyl moiety is substituted by an amino, C₁₋₃-alkylamino, or di-(C₁₋₃-alkyl)-amino group,

a C₃₋₇-cycloalkyl-C₁₋₂-alkyl group wherein the cycloalkyl moiety is substituted by an amino-C₁₋₃-alkyl, C₁₋₃-alkylamino-C₁₋₃-alkyl, or a di-(C₁₋₃-alkyl)amino-C₁₋₃-alkyl group,

a C₃₋₇-cycloalkylamino group wherein the cycloalkyl moiety is substituted by an amino, C₁₋₃-alkylamino, or di-(C₁₋₃-alkyl)-amino group, and the two nitrogen atoms on the cycloalkyl moiety are separated from one another by at least two carbon atoms,

an N-(C₃₋₇-cycloalkyl)-N-(C₁₋₃-alkyl)-amino group wherein the cycloalkyl moiety is substituted by an amino, C₁₋₃-alkylamino, or di-(C₁₋₃-alkyl)-amino group, and the two nitrogen atoms on the cycloalkyl moiety are separated from one another by at least two carbon atoms,

a C₃₋₇-cycloalkylamino group wherein the cycloalkyl moiety is substituted by an amino-C₁₋₃-alkyl, C₁₋₃-alkylamino-C₁₋₃-alkyl, or a di-(C₁₋₃-alkyl)amino-C₁₋₃-alkyl group,

an N-(C₃₋₇-cycloalkyl)-N-(C₁₋₃-alkyl)-amino group wherein the cycloalkyl moiety is substituted by an amino-C₁₋₃-alkyl, C₁₋₃-alkylamino-C₁₋₃-alkyl, or a di-(C₁₋₃-alkyl)amino-C₁₋₃-alkyl group,

a C₃₋₇-cycloalkyl-C₁₋₂-alkyl-amino group wherein the cycloalkyl moiety is substituted by an amino, C₁₋₃-alkylamino, or di-(C₁₋₃-alkyl)-amino group,

an N-(C₃₋₇-cycloalkyl-C₁₋₂-alkyl)-N-(C₁₋₂-alkyl)-amino group wherein the cycloalkyl moiety is substituted by an amino, C₁₋₃-alkylamino, or di-(C₁₋₃-alkyl)-amino group,

a C₃₋₇-cycloalkyl-C₁₋₂-alkyl-amino group wherein the cycloalkyl moiety is substituted by an amino-C₁₋₃-alkyl, C₁₋₃-alkylamino-C₁₋₃-alkyl, or a di-(C₁₋₃-alkyl)amino-C₁₋₃-alkyl group,

an N-(C₃₋₇-cycloalkyl-C₁₋₂-alkyl)-N-(C₁₋₂-alkyl)-amino group wherein the cycloalkyl moiety is substituted by an amino-C₁₋₃-alkyl, C₁₋₃-alkylamino-C₁₋₃-alkyl, or a di-(C₁₋₃-alkyl)amino-C₁₋₃-alkyl group,

an R¹⁹-C₂₋₄-alkylamino group wherein R¹⁹ is separated from the nitrogen atom of the C₂₋₄-alkylamino moiety by at least two carbon atoms,

an R¹⁹-C₂₋₄-alkylamino group wherein the nitrogen atom of the C₂₋₄-alkylamino moiety is substituted by a C₁₋₃-alkyl group and R¹⁹ is separated from the nitrogen atom of the C₂₋₄-alkylamino moiety by at least two carbon atoms,

an amino group substituted by R²⁰,

an amino group substituted by R²⁰ and a C₁₋₃-alkyl group, wherein R²⁰ is optionally independently substituted by one or two C₁₋₃-alkyl groups,

an R¹⁹-C₃₋₄-alkyl group wherein the C₃₋₄-alkyl moiety is straight-chained and is optionally additionally substituted by one or two C₁₋₃-alkyl groups,

a 3-amino-2-oxopiperidin-5-yl or 3-amino-2-oxo-1-methylpiperidin-5-yl group,

a pyrrolidin-3-yl, piperidin-3-yl, piperidin-4-yl, hexahydroazepin-3-yl, or hexahydroazepin-4-yl group substituted in the 1 position by an amino, C₁₋₃-alkylamino, or di-(C₁₋₃-alkyl)amino group, or

an azetidin-2-yl-C₁₋₂-alkyl, azetidin-3-yl-C₁₋₂-alkyl, pyrrolidin-2-yl-C₁₋₂-alkyl, pyrrolidin-3-yl, pyrrolidin-3-yl-C₁₋₂-alkyl, piperidin-2-yl-C₁₋₂-alkyl, piperidin-3-yl, piperidin-3-yl-C₁₋₂-alkyl, piperidin-4-yl, or piperidin-4-yl-C₁₋₂-alkyl group, optionally independently substituted by one or two C₁₋₃-alkyl groups;

R¹⁹ is an amino, C₁₋₃-alkylamino, or di-(C₁₋₃-alkyl)-amino group; and

R²⁰ is an azetidin-3-yl, azetidin-2-ylmethyl, azetidin-3-ylmethyl, pyrrolidin-3-yl, pyrrolidin-2-ylmethyl, pyrrolidin-3-ylmethyl, piperidin-3-yl, piperidin-4-yl, piperidin-2-ylmethyl, piperidin-3-ylmethyl, or piperidin-4-ylmethyl group, each optionally substituted by one or two C₁₋₃-alkyl groups,

wherein:

each alkyl, alkenyl, and alkynyl group is independently straight-chained or branched, unless otherwise stated,

each aryl group is independently a phenyl or naphthyl group optionally mono- or disubstituted by R_h, where the substituents are identical or different, and

each heteroaryl group is independently a pyrrolyl, furanyl, thienyl, pyridyl, indolyl, benzofuranyl, benzothiophenyl, quinolinyl, or isoquinolinyl group,

or a pyrrolyl, furanyl, thienyl, or pyridyl group wherein one or two methyne groups are replaced by nitrogen atoms,

an indolyl, benzofuranyl, benzothiophenyl, quinoliny, or isoquinoliny group wherein one to three methyne groups are replaced by nitrogen atoms, or

a 1,2-dihydro-2-oxopyridiny, 1,4-dihydro-4-oxopyridiny, 2,3-dihydro-3-oxopyridaziny, 1,2,3,6-tetrahydro-3,6-dioxopyridaziny, 1,2-dihydro-2-oxopyrimidinyl, 3,4-dihydro-4-oxopyrimidinyl, 1,2,3,4-tetrahydro-2,4-dioxopyrimidinyl, 1,2-dihydro-2-oxopyraziny, 1,2,3,4-tetrahydro-2,3-dioxopyraziny, 2,3-dihydro-2-oxoindolyl, 2,3-dihydrobenzofuranyl, 2,3-dihydro-2-oxo-1*H*-benzimidazolyl, 2,3-dihydro-2-oxobenzoxazolyl, 1,2-dihydro-2-oxoquinoliny, 1,4-dihydro-4-oxoquinoliny, 1,2-dihydro-1-oxoisoquinoliny, 1,4-dihydro-4-oxocinnoliny, 1,2-dihydro-2-oxoquinazoliny, 3,4-dihydro-4-oxoquinazoliny, 1,2,3,4-tetrahydro-2,4-dioxoquinazoliny, 1,2-dihydro-2-oxoquinoxaliny, 1,2,3,4-tetrahydro-2,3-dioxoquinoxaliny, 1,2-dihydro-1-oxophthalaziny, 1,2,3,4-tetrahydro-1,4-dioxophthalaziny, chromanyl, cumariny, 2,3-dihydrobenzo[1,4]dioxiny, or 3,4-dihydro-3-oxo-2*H*-benzo[1,4]oxaziny group,

wherein each heteroaryl group is independently mono- or disubstituted by R_h, where the substituents are identical or different, and

R_h is a fluorine, chlorine, bromine, or iodine atom, a trifluoromethyl, cyano, nitro, amino, aminocarbonyl, aminosulfonyl, methylsulfonyl, acetylamino, methylsulfonylamino, C₁₋₃-alkyl, cyclopropyl, ethenyl, ethynyl, hydroxy, C₁₋₃-alkyloxy, difluoromethoxy, or trifluoromethoxy group,

or a prodrug or salt thereof.

2. A compound of general formula (I) according to claim 1, wherein:

R⁴ is a pyrrolidin-1-yl group substituted in the 3 position by an amino group, a piperidin-1-yl group substituted in the 3 position by an amino group, a hexahydroazepin-1-yl group substituted in the 3 position or 4 position by an amino group, a (2-aminocyclohexyl)amino group, a cyclohexyl group substituted in the 3 position by an amino group, or an *N*-(2-aminoethyl)methylamino or an *N*-(2-aminoethyl)ethylamino group,

or a prodrug or salt thereof.

3. The compound of general formula (I) according to claim 2, wherein:

R¹ is a phenylcarbonylmethyl group wherein the phenyl moiety is substituted by R¹⁰, wherein:

R¹⁰ is a formylamino, C₃₋₇-cycloalkyl-carbonylamino, C₃₋₇-cycloalkyl-C₁₋₃-alkyl-carbonylamino, C₆₋₉-bicycloalkyl-carbonylamino, (1,3-dioxolanyl)carbonylamino, (1,4-dioxanyl)carbonylamino, morpholin-2-ylcarbonylamino, morpholin-3-ylcarbonylamino, piperazin-2-ylcarbonylamino, C₅₋₇-cycloalkenyl-carbonylamino, C₅₋₇-cycloalkenyl-C₁₋₃-alkyl-carbonylamino, C₃₋₇-cycloalkyl-sulfonylamino, phenylsulfonylamino, phenyl-C₁₋₃-alkyl-sulfonylamino, or a pyridinylcarbonylamino group,

a C₅₋₇-cycloalkyl-carbonylamino group wherein a methylene group is replaced by an oxygen or sulfur atom or by an imino, sulfinyl, or sulfonyl group,

a C₅₋₇-cycloalkyl-carbonylamino group wherein a -CH₂-CH₂ group is replaced by an -NH-CO group,

C₅₋₇-cycloalkyl-carbonylamino group wherein a -CH₂-CH₂-CH₂ group is replaced by an -NH-CO-O group, or

a C₅₋₇-cycloalkyl-carbonylamino group wherein a methylene group is replaced by a carbonyl group;

R² is a hydrogen atom, or a C₁₋₃-alkyl group;

R³ is a C₄₋₆-alkenyl, 2-butyne-1-yl, or 1-cyclopenten-1-ylmethyl group; and

R⁴ is a piperidin-1-yl group substituted in the 3 position by an amino group, a hexahydroazepin-1-yl group substituted in the 3 position or 4 position by an amino group, a (2-aminocyclohexyl)amino group, a cyclohexyl group substituted in the 3 position by an amino group, or an *N*-(2-aminoethyl)methylamino or an *N*-(2-aminoethyl)ethylamino group,

or a prodrug or salt thereof.

4. The compound of general formula (I) according to claim 3, wherein:

R¹ is a phenylcarbonylmethyl group wherein the phenyl moiety is substituted by a formylamino, pyridinylcarbonylamino, or cyclopropylcarbonylamino group;

R² is a methyl group;

R³ is a 2-buten-1-yl, 3-methyl-2-buten-1-yl, or a 2-butyne-1-yl group; and

R⁴ is a (3-aminopiperidin-1-yl) group,

or a prodrug or salt thereof.

5. The compound of general formula (I) according to claim 4, wherein:

R¹ is a [2-(cyclopropylcarbonylamino)phenyl]carbonylmethyl or [2-(pyridylcarbonylamino)phenyl]carbonylmethyl group;

R² is a methyl group;

R³ is a 2-buten-1-yl, 3-methyl-2-buten-1-yl, or a 2-butyne-1-yl group; and

R⁴ is a (3-aminopiperidin-1-yl) group,

or a prodrug or salt thereof.

6. A compound selected from:

- (1) 1-[2-(2-formylaminophenyl)-2-oxoethyl]-3-methyl-7-(3-methyl-2-buten-1-yl)-8-(3-aminopiperidin-1-yl)xanthine;
- (2) 1-(2-{2-[(cyclopropylcarbonyl)amino]phenyl}-2-oxoethyl)-3-methyl-7-(3-methyl-2-buten-1-yl)-8-(3-aminopiperidin-1-yl)xanthine;
- (3) 1-[2-(2-formylaminophenyl)-2-oxoethyl]-3-methyl-7-(2-butyne-1-yl)-8-(3-aminopiperidin-1-yl)xanthine;
- (4) 1-(2-{2-[(cyclopropylcarbonyl)amino]phenyl}-2-oxoethyl)-3-methyl-7-((*E*)-2-buten-1-yl)-8-((*R*)-3-aminopiperidin-1-yl)xanthine;
- (5) 1-(2-{2-[(cyclopropylcarbonyl)amino]phenyl}-2-oxoethyl)-3-methyl-7-((*E*)-2-buten-1-yl)-8-((*S*)-3-aminopiperidin-1-yl)xanthine;
- (6) 1-(2-{2-[(cyclopropylcarbonyl)amino]phenyl}-2-oxoethyl)-3-methyl-7-(2-butyne-1-yl)-8-((*R*)-3-aminopiperidin-1-yl)xanthine;

- (7) 1-(2-{2-[(cyclopropylcarbonyl)amino]phenyl}-2-oxoethyl)-3-methyl-7-(2-butyln-1-yl)-8-((*S*)-3-aminopiperidin-1-yl)xanthine; and
- (8) 1-[2-(2-{[(pyridin-2-yl)carbonyl]amino}phenyl)-2-oxoethyl]-3-methyl-7-((*E*)-2-buten-1-yl)-8-(3-aminopiperidin-1-yl)xanthine,

or a prodrug or salt thereof.

7. The compound of formula (I) according to claim 1, wherein the compound is a physiologically acceptable salt.

8. The compound of formula (I) according to claim 2, wherein the compound is a physiologically acceptable salt.

9. The compound of formula (I) according to claim 3, wherein the compound is a physiologically acceptable salt.

10. The compound of formula (I) according to claim 4, wherein the compound is a physiologically acceptable salt.

11. The compound of formula (I) according to claim 5, wherein the compound is a physiologically acceptable salt.

12. The compound of formula (I) according to claim 6, wherein the compound is a physiologically acceptable salt.

13. A pharmaceutical composition comprising a compound of formula (I) according to one of claims 1 to 12 and an inert carrier or diluent.

14. The pharmaceutical composition according to claim 13, wherein the compound of formula (I) is incorporated with the inert carrier or diluent by a non-chemical method.

15. A method of treating type I and type II diabetes mellitus, arthritis, obesity, allograft transplantation, or calcitonin-induced osteoporosis in a patient in need thereof comprising administering to the patient a compound of formula (I) according to one of claims 1 to 12.